# Study on Equipment Qualification Technology of MOV actuator for Continued Operation

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## 1. Introduction

EQ(Equipment Qualification) technology for various equipment and components is needed for continued operation of operating NPPs(Nuclear Power Plants) whose design life will be finished. If the qualified life of operation equipment is longer than extension life, EQ test is not required. Otherwise, EQ test of the equipment should be performed to qualify equipment operability during extension life according to industrial standard IEEE 323[1]. Refurbishment for the components aged by temperature, humidity, vibration and radiation for a long time, for example 30 years in case of Kori #1, might be performed together with EQ test.

In this paper, EQ technology accompanying with refurbishment of MOV(Motor Operated Valve) actuator operating in Kori #1 was developed for continued operation of 10 years.

## 2. Test Specimen and Facilities

*2.1 Test Specimen*

Test specimen of MOV actuator is HOP-9151 which is made by HOPKINSONS. The actuator is structurally separated by three parts of motor, gear and switch.

*2.2 Test Facilities*

Test facilities for this study are presented in Table 1. Almost equipment had been pre-constructed. But facilities which can determine torque & revolution of actuating axis and operating time were constructed for operability test. Related equipment is torque meter, tachometer and data acquisition. Control box was also constructed to operate actuator and verify that's operation.

## 3. Test Procedures for Equipment Qualification

*3.1 Equipment Qualification Procedure Considering Refurbishment*

New manufactured MOV actuator is normally performing EQ test according to procedures regulated by IEEE 323 and IEEE 382[2]. But equipment operating in NPP may be needed to perform refurbishment process with as shown in Fig. 1. The actuator could be subjected to expose again and again aging or accident conditions after refurbishing the components because there is high possibility of operation failure by aged components despites refurbishment before qualification testing,

Radiation aging test of HOP 9151 actuator is omitted because radiation does rate is negligible in installed position of NPP. Also, Vibration aging test and Seismic test are not performed due to small mass change after refurbishment as qualified equipment in past time. In general, the range of mass change not to consider vibration effects is not more than 5 %.

*3.2 EQ Testing*

First of all, mainly aged components are selected by Pre-inspection test. The aged components are almost non-metallic material as shown in Table 2. All aged components are changed into applicable and high-quality components because those qualities are very low as components produced 30 years ago.

Baseline operability test establishes reference performance data for comparison with performance data at other stages of the qualification test program. Reference data on operability of MOV actuator are following lists.

① Output speed in each direction under no-load conditions at nominal input supply (voltage pressure)
② Operating time in each direction under simulated load conditions

Table 1. Test facilities

| List | Facility |
|---|---|
| Operability test | Powder brake, Viper 20, Torque meter, Tachometer, DAQ |
| Thermal aging test | Electric oven |
| DBE test | Boiler, Superheater, Test chamber |
| ETC | Tester, Control box |

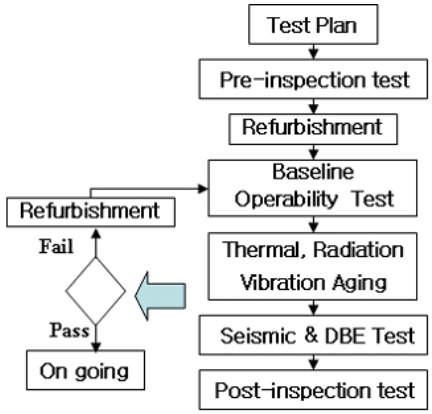



Fig. 1 EQ test procedure with refurbishment

Table 2. Refurbishment list of HOP 9151

| No. | Refurbishment list | Remark |
|---|---|---|
| 1 | O-ring, grease | Replacement |
| 2 | Insulation winding | Rewinding |
| 3 | Gear set | Alum |
| 4 | Limit switch, Torque switch | Replacement |
| 5 | Axis , housing of gear part | Extension |

③ The operating output torque or thrust characteristics under the minimum specified input supply (voltage pressure)
③ Confirmation of proper torque, limit, and auxiliary switch action)

Operability test is performed in after all the tests and during accident test. Acceptance criteria of MOV actuator which is presented in KEPIC MOC 5120[3] is that change of reference operating time operability is not excess 15 %.

Thermal aging test is to expose actuator into condition of high temperature calculated by Arrhenius equation such as Eq. (1). Arrhenius equation is based on increase of chemical reaction rate as temperature rises.

$$\ln \frac{t_2}{t_1} = \frac{E_a}{k}\left(\frac{1}{T_2} - \frac{1}{T_1}\right) \qquad (1)$$

where $t_2$ is duration of accelerated aging [sec], $t_1$ is life time to which component is to be aged, $T_2$ is accelerated aging temperature [K], $T_1$ is average operating temperature [K]. Activation energy ($E_a$) of the nonmetallic components for thermal aging test is analyzed. Ea of this test apply conservatively 0.8 eV which is presented in IEEE 382 in spite that minimum $E_a$ in analyzed data is 0.84 eV.

After thermal aging test, MSLB of DBE(Design Basis Event) tests is performed as temperature profile shown in Fig.2. Maximum temperature of that profile is 215 °C. Test duration of MSLB is 72 hours. Operability test while testing MSLB is performed at peak temperature during 100 seconds interval.

After DBE test, post operability test and post inspection test is performed. Post inspection test check the inside and outside appearance of the actuator such as color, leak and crack.

## 4. Results of EQ Test

After refurbishment, actuating axis was extended to 14 mm due to replacement of limit and torque switch. Gears of plastic material are changed into aluminum. Also, insulation class of aged motor winding is changed C class (<155 °C) into F class (180 °C>). Insulation class of motor represents limiting hot spot temperature of motor winding. 4.0 % (730 g/18.2 kg) of total mass of the actuator is increased by refurbishment.

Results of each operability test are shown in Table 3. Operating time($T_o$) is changed to maximum 0.9 % as shown in Fig. 3. In post inspection test, discolor and blister of outer coating, grease leakage and hardness of cables is discovered. But these have no relation with operability of MOV actuator.

## 5. Conclusion

MOV actuator operating in NPP can qualify operability by EQ test accompanying refurbishment which changes aged components into new ones.

| Performance | | Baseline | Post thermal aging | During DBE | Post DBE |
|---|---|---|---|---|---|
| No load, RPM in 480 V | Opening | 30.4 | 30.4 | - | - |
| | Closing | 30.4 | 30.4 | - | - |
| **Load(100 Nm), $T_o$ in 480 V** | **Opening** | **126.8** | **126.2** | **125.9** | **133.5** |
| | **Closing** | **128.0** | **128.7** | **127.9** | **131.6** |
| Load(100 Nm), RPM in 380 V [Nm] | Opening | 112.9 | 106.3 | - | - |
| | Closing | 112.3 | 114.5 | - | - |
| Switch Operability | Opening | O | O | X | X |
| | Closing | O | O | O | O |

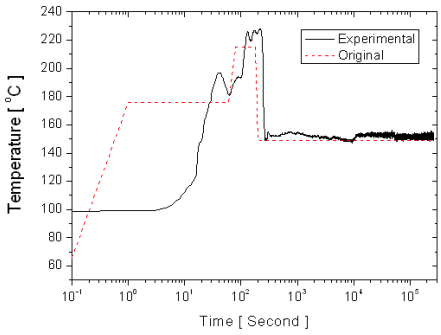
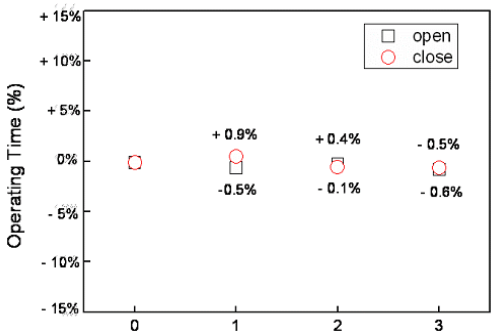



Fig.2 MSLB temperature profile




(0: Baseline 1. Post thermal aging 2. During DBE, 3. Post DBE)

Fig.3 Operating time of MOV actuator

Aged components are almost nonmetallic materials such as o-ring, motor winding, gear, limit switch and torque switch. Grease and oil is also aged components.

This EQ procedure of MOV actuator could be applicable to all equipment operating in NPP for continued operation. In the future, refurbishment technology for EQ test is also largely economical effects.

## REFERENCES

[1] IEEE 323, "Qualifying class 1E equipment for nuclear power generating station" (2003).
[2] IEEE 382, "Qualification of actuators for power-operated valve assemblies with safety-related functions for nuclear power plants" (1996).
[3] KEPIC MOC 5120, "Electrical operated valve"(2001)